

used to grow in the tunnels, I think we may safely take it for granted that fungi are, or were, deleterious to weak lungs. The next question then is how to get rid of them? The manager of the Long Tunnel at any rate has answered this question, to a certain extent, in a very practical way, for his repairs have nearly extirpated the fungi from some of the levels. But if we turn again to professor Berkeley's "Outlines," we find the following: "The rapidity with which spawn penetrates, and the depth to which it enters, is often quite surprising. The most solid timber in a few months will sometimes show unequivocal traces of spawn. I have seen, for instance, elm trunks which were perfectly sound when felled, penetrated by the end of the second year with spawn to within a few inches of the centre; and in this case it must be remembered that vegetation goes on in the trunk for nearly a twelvemonth before any fungi can establish themselves." Now it is simply absurd to suppose that a mining company could keep on constantly renewing timber to keep down these destructive pests. Several gentlemen belonging to our Society suggested painting the timber with certain acids, and I intended to try this plan at Walhalla, but my short stay prevented me; however, I have asked the manager, Mr. Ramsay Thomson, to paint certain marked posts with different acids, and so find out which is the best, and I have little doubt that he will accede to my request. The following remedies are mentioned by Berkeley—salt, lime, sulphate of copper, corrosive sublimate, and arsenic. If we are fortunate enough to hit on a really good and cheap remedy, we will not only be able to show how to extirpate an enemy to human life, but also to offer a premium to mine owners to use the remedy, for if the fungi in mines can be destroyed the timber will most certainly last twice as long.

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ART. V.—*On the Production of Colour in Birds' Eggs.*

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The question of the cause of the coloration of birds' eggs has often been referred to, but has not, to my knowledge, been adequately treated of in any work on Oology. Perhaps

we may consider the latest views on the subject to be those enunciated by Mr. H. Seebohm in his lecture at the London Institution, December 20, 1886. I had published in the *Melbourne Leader* of December 26, 1885, a popular account of the colours of Australian birds' eggs, in which I advanced suggestions which seemed to me to throw light on the subject. After reading the abstract in *Nature* of the interesting lecture by this high authority, I have thought it worth while to make a more formal scientific record of the ideas broached in the *Leader*.

My hypotheses may well be encountered with criticism, but they do serve at least very conveniently to connect a multitude of facts together. The antiquity of the Australian Avi-Fauna, and the preservation of ancient types, render a comprehensive consideration of Australian eggs of the greater value. My suggestions have been founded on studies of large collections, and after a certain amount of experience in the field. Australian eggs yield a rich abundance of facts which are of scientific interest *per se*, and which will be of still higher value if we can discern their bearing on biological problems.

We take it that the natural or original colour of birds' eggs is the pure white of the mineral substance (carbonate of lime) of which they are composed, just as the natural colour of bone is white, and that, too, of the shells of mollusca, &c. All shells are secreted by animal membranes. In the mollusca, an external layer of membrane usually remains free from admixture of mineral matter, as an animal epidermis, which can be peeled off. But this is not the case with birds' eggs; they possess a membranous lining, generally white, occasionally brownish or bluish, but outside this the animal substance and mineral matter are intimately commingled to the very surface. Colour, if produced, is then, in almost all eggs, ingrained. Often it can be detected incorporated in the inner layers of the shell, as blotches beneath the surface.

Birds' eggs have many foes. Even where man has not appeared upon the scene, a number of systematic nest-robbers exist. Snakes, the great lace-lizard (*Hydrosaurus* or *Varanus varius*), which takes such liberties with the settlers' hen roosts, the "native cats" (*Dasyurus viverrinus* and *D. maculatus*), perhaps the bush rats, and last, but by no means least, other birds, and especially the crows, are very destructive of our native birds' eggs, and of the young birds

in the nest. To such intruders pure white eggs would be a conspicuous and gratuitous advertisement, and the birds would be exposed to undue danger while in the egg. As has been remarked hundreds of times before, we accordingly find that white eggs, and especially eggs of shining or pearly whiteness, are almost always found in nests which either conceal the eggs completely, or which are themselves completely concealed. Thus the cookatoos, parrots, parrakeets, and other members of the family, in almost all cases, build in holes of trees, usually high up and quite out of reach. Owls build in holes of large gum trees; kingfishers, including the laughing jackass (*Dacelo gigas*), in holes of trees or banks; the diamond birds, the roller, and bee-eater, in holes in trees or in burrows. The penguins and many of the petrels lay their eggs at the extremities of long burrows in the ground, facing the sea. The eggs of all of these groups of birds are white.

The eggs of the doves, pigeons, and podarguses are beautifully white, often shining as if enamelled. The birds construct slight nests of twigs, placed crosswise on horizontal branches of trees. Much light can pass through the interstices between the twigs, and it is a difficult matter, even for the trained human eye, to detect from below whether there are eggs in the nest or not. Here the white, light-reflecting eggs are at a positive advantage.

The Australian finches conceal their eggs in the depths of relatively huge covered baggy nests, provided with side spout-like entrances. The eggs are in no way visible from without, are securely stowed away, and are pure white. All of the English finches, on the contrary, lay in open nests, and the eggs are spotted, usually, too, on a neutral-tinted ground. In this case we may presume that we have preserved the ancestral type in Australia.

Since a glaring uniform white must be a dangerous colour for exposed eggs, we are not surprised to find that variations, favourable to preservation, have been originated and preserved, and that colour is now a protection to the great majority of eggs. In all cases we have to consider two questions: (1) How could the colour have been acquired? and (2) How is the colour now protective or otherwise beneficial? That natural selection would be called into play to preserve favourable markings or tints we may allow, but we believe, with Mr. Seebohm, that "natural selection is not the cause of evolution" in this case, "but only its guide."

The first question then is, how could the colour have been acquired? and I do not know that anyone has attempted hitherto to give any answer to it. The following has occurred to me as a probable explanation of the process; at least the phenomena are referred back to principles already recognised.

In the first place, it is important to note that the shell of the ovum is formed in the third portion of the oviduct ("the uterus"), and entirely during the 12-18 hours which immediately precede the expulsion or laying of the egg. This is the length of the period in the case of the common fowl; we may assume, generally, a similar number of hours, probably shorter, in the case of the smaller species. That the formation of the shell is a process distinct from the formation of the yolk, is further brought before us strikingly, by an experiment of M. Tarkhanoff. He introduced a small ball of amber into the upper part of the ovarium, and obtained later on a quite normal egg, with chalazæ, albumen, and shell, but with the ball of amber in place of a yolk.

At the breeding season, the females of certain animals are well-known to be especially impressionable, and we think that the effect of the surroundings during the time of the formation of the shell, upon the mental or nervous constitution of the bird, is a main factor in the production of colour in the eggs. Any variations of value are seized on by natural selection, and transmitted by the principle of heredity. Individuals at the present day are influenced in part by the surroundings, but mainly restricted by the tribal habits of generations. We have, in fact, sufficient adherence to type for an experienced collector to be tolerably sure of the species of bird to which a particular egg belongs, but sufficient variation to make him wonder at the differences which often exist between eggs of the same clutch. As we find in all groups, that some species are more stable and less variable than others, so the eggs of some birds are apparently fixed in colour and pattern, while those of others vary within wide limits.

We will now consider in detail, the influence of surroundings, and the utility of the effects produced.

The general tint of the egg is often protective. The colour of the ground prominently before the vision of the laying bird, is reproduced in various shades in the eggs of the pheasants and partridges, and in our mallee hen (*Leipoa ocellata*) and megapode. In the rich brown

variety of the egg of the domestic fowl, we probably see the colour developed in the feral state, now usually lost by reversion to the original white, as there is no longer advantage to be gained by its retention.

In addition to the protective ground tint, darker spots and markings lend further security. The eggs of the sandpipers and dottrells cannot be distinguished, even when seen, from the sands on which they lie, without close concentration of the attention. Grouse and quail, rails and night-jars, plovers and terns, oyster-catchers and gulls, all lay on the ground, with or without nests, and the eggs exhibit different shades of the soil or of the rocks, with an appropriate ornamentation of spots, blotches, and smears.

White eggs become similarly less conspicuous if the white be broken up, by the introduction of spots or blotches of shading. This is a very simple, but by no means, ineffective means of avoiding detection. The eggs of the Australian shrike-thrushes, white-winged corcorax, and frontal shrike-tits, are good instances of exposed white eggs so protected. In many families it is noteworthy that those kinds of eggs which are quite concealed are white, while those which are exposed are speckled or freckled. In the tree swallows and martins, we find a graduated series. The eggs of the English sand-martin, laid at the ends of tunnels in soft sandstone, are quite white. Those of the Australian tree-martin which lays in spouts of trees, are very slightly spotted. Those of the fairy martin, laying in social colonies, under the eaves of houses, &c., are more freely flecked. Lastly, the English swallow, and the Australian welcome swallow, which builds under bridges, or in shallow spouts of trees, in more exposed situations, are plentifully covered with spots. So amongst English titmice (a family wanting in Australia), the only purely white eggs are those of the long-tailed titmouse, whose long and roomy mossy nest, with side entrance, often contains a clutch of a dozen or fourteen eggs. The warblers, the larks, and the honey-eaters, are other families of birds with spotted eggs.

The experiments of Jacob (Genesis xxx. 37-43) are recorded as having been successful in producing mottled colours in the animals under his charge. By the simple device of placing green rods before them at the time of conception, in which he "pilled white strakes, and made the white appear which was in the rods." "And the flocks conceived before the rods, and brought forth cattle ring-

straked, speckled and spotted." It is then not difficult to understand that surrounding objects of very different appearance, but of unequally coloured surface, might as readily produce spots and speckles on bird's eggs, as on the skins of mammals.

In the case of the honey-eaters, we may venture a surmise as to what the parti-coloured objects are which produce the spotted eggs. The eggs of these birds are of various shades of ground colour, white, buff, salmon, flesh-coloured, with small dots or flecks of purple, chestnut, reddish-brown, or even black. The birds, as their name denotes, may be seen busily extracting the honey from the flowers by means of their long tongues. Familiarity with pale and warm-tinted flowers and with the dotted orange, red, purple, or black anthers, may possibly account for the coloration of this type of egg.

Many birds which nest in trees or bushes have eggs which are of a pale or darker green ground hue, speckled or splashed over with olive or brown, reminding one of the different shades of the surrounding foliage, and, moreover, difficult to see from a distance through a bower of leaves. Such are the eggs of the crows, magpies, and crow-shrikes, the species of *grauculus*, the English black-birds, and the Australian mountain thrush and robins. In this case both origin and use of the colour are apparent.

Eggs with irregular streaky lines of bizarre appearance are found in a few families. In England, the yellow-hammers and buntings are good examples. In Australia, we have the *Pomatostomi*. The eggs of the latter are about an inch long and three-quarters of an inch at the widest, olive-brown, with all kinds of hieroglyphic pencillings in black. Both families line their nests with hair, and the eggs are protected by their resemblance to the lining of the nest. Gould similarly remarks, in speaking of the Victorian lyre-bird, "the colour resembles, in fact so closely, that of the feathers with which the nest is lined, that it is not easy to detect the egg."

Eggs of a pale bluish or greenish uniform tint are common. Such neutral tints are found in the grebes, cormorants, swans, ducks, and geese, the mangrove bitterns, the glossy ibis; and attaining to the deepest and loveliest shade in the herons. Just as the hue of the eggs of the pheasants, &c., may have been suggested by that of mother earth ever before their eyes, so these tints of the water birds' eggs may have arisen from the contemplation of vast sheets of water.

and the consequent impression upon the mental organisation of the parents. This peculiarity of colour, too, has been of service in rendering the eggs less easy of detection, as being of neutral hues, or as resembling, more or less, the water around or near the nest.

But the brightest blues of all occur, very exceptionally, in groups of birds of totally different habits, in no way adapted to an aquatic life. Such are, for instance, amongst English birds, the thrush and the starling, the hedge sparrow and lesser redpole, the wheatear, and to a less extent, the stone-chat and whin-chat. Amongst Australian birds, are those of the naturalised Indian or Ceylon mynah, the coach-whip bird, and the wedge-bill, and the species of *Zosterops*, a small family allied to the honey-eaters. Such examples, it is to be noted, are extremely scarce. It is difficult to surmise the causes which can have combined to produce this unique coloration. If the "motive" be protection, it must fall under the general principle, that intruders are shy of the brightly coloured objects. Some support for this view may be derived from Mr. Bates' well-known observations on deterrent colours amongst insects. It is difficult, moreover, to discover a blue in the surroundings of the birds, which could produce so pronounced a mental conception of this colour. It may be the blue of the butterflies on which they feed. It may be the blue of the aerial vault above. It would seem, if this second suggestion be the right one, that very few indeed of the birds have their attention attracted strongly by the azure of the skies, while they occupy their aerial homes.

The eggs of the ostrich vie in colour with the pale yellow sand of the African desert, in which they are buried for the sake of incubation by the sun's heat; but those of the emu, laid in the Australian bush, are, as every one knows, dark green. Here we have an indication that the Australian bush is not made up of yellow sandy deserts. The emu, in fact, scoops out a hole in the ground amongst low scrub, and contemplates eucalypts and salt-bush, and other dull vegetation. Its eggs are exposed and protected by their colour. The cassowary, laying and living amongst the bright green of the tropical grasses, and the vivid green of a more diversified tropical foliage, produces lighter and brighter green eggs.

With the birds of prey the mental perception of habitual surroundings seems to have been intense (as might have been

expected from their known keenness of vision), and the influence upon the colouring of the eggs remarkable. The nests of the eagles, falcons, and hawks are large, and exposed on the tops of trees or on the ledges of lofty cliffs. The eggs are generally more or less blotched with rusty red, presenting a marked resemblance to old blood spots, such as the family are so well acquainted with. The nankeen kestrel breeds in spouts of trees, where, of course, the colour cannot be protective, yet the eggs retain the family peculiarity. Here we see natural selection apparently ruled out of court, and mental receptivity as the sole cause of the variations in the one specified direction. The eggs of the other members of the family are, from their situation, inaccessible, and it therefore seems very questionable whether the factor of natural selection has operated at all in the case of the eggs of this group.

We find very different degrees of development of the blotches. In one clutch of the sparrow-hawk (*Accipiter torquatus*) one egg was white, a second smudged, and the third well blotched. In a clutch of the goshawk (*Astur approximans*), again, one egg was smudged, one smudged and blotched, and the other blotched. Similar gradations are to be observed in the average colour of the species. The eggs of the harriers (*Circus*), which lay on or near the ground, and generally among thick scrub, and those of the crested hawk (*Baza subcristata*), which builds in the holes of trees, are pure white; and we have gradually more and more colour introduced, until the climax is reached by the brown hawks (*Jeracidea berigora*) and kestrels (*Tinnunculus cenchroides*).

Great irregularity and much play of variation amongst individuals, characterise eggs, which derive their colour from changing and varying appearances. We obtain thus a natural explanation of the infinite variety of colouring in the eggs of the rapacious birds, and of such birds as the magpies and the sparrows.

Many birds continue to protect their eggs themselves, consciously or unconsciously. Some, as the partridge, will cover up the eggs when they leave the nest. The grebes lay eggs which are at first white, but become stained by mud from the body of the sitting mother bird, usually brown and gradually browner, a tint well in keeping with the colour of the nest, of the dead reeds and leaves. Many of

the sea birds, too, by fouling their eggs, no doubt materially assist in preserving them.

The English cuckoo commonly chooses the nests of larks or of wagtails for its egg. When found in the nest of a lark, especially of a tit-lark, the egg is very dark; and when found in that of a wagtail, much lighter. This looks like proof positive of the effect of mental impression in producing the colour of the egg. More rarely, the egg of the cuckoo is found in other nests, such as that of the hedge sparrow. It is most likely that in this case, the cuckoo had in the course of nature laid its egg, and not being able to find an appropriate nest near, was driven to make use of that readiest to hand. For nothing could be more conspicuous than the contrast between the colours of the eggs. Our Victorian cuckoos are likewise eclectics. The pallid cuckoo often plants its cream or flesh-coloured and spotted eggs in the nests of honey-eaters, the eggs of which its own thus resemble. The bronze cuckoo patronises the dome-shaped nests of little birds, in which the egg will not be seen, and into which it doubtless conveys its egg by means of the bill, for the cuckoo is much too large a bird to obtain entrance into the nest by the tiny opening which serves for the rightful owners. The brush and the narrow-billed cuckoos place their eggs in the nests of superb warblers and acanthizas, and the eggs of both are white, with very fine dots.

The subject it will be seen is as yet still entirely in the domain of observation. Experiments are wanting. It is to be hoped that they will be forthcoming. Opportunities exist, notably in the case of the domestic birds, and of birds which breed easily in confinement. But we must not expect too much, to be able to produce extreme effects. Mr. E. B. Poulton's interesting series of experiments on the production of colour in the pupæ of certain British Lepidoptera, show that the capacity for variation in each species is (for a single generation) limited, and that the variations tend in quite definite directions. It is probable, however, that results of sufficient, and perhaps in some cases of striking, interest are to be obtained by careful and systematic experimentation. And the field is open.